

Experimental Procedure

(Perform with a partner during the lab. Partner's name _____)
Part 1: Density of Water

You are first going to determine the density of water. Don't forget to include units on each measurement.
1) Measure and record the mass of a dry 10 mL graduated cylinder to as many decimal places as is provided by the balance.

Mass of Graduated Cylinder: 36.05 g

2) Add anywhere from 5 to 9 mL of water to the graduated cylinder. Record the volume to the nearest hundredth mL because that represents the precision of this measuring device.

Volume of Water: 6.05 mL

3) Find the mass of the graduated cylinder and water together. Record all digits.

Mass of Graduated Cylinder and Water: 41.97 g

4) Find the mass of the water by subtracting the mass of the graduated cylinder from the mass of the graduated cylinder and water combined. Make sure you round to the correct decimal place.

Mass of Water: 5.82

5) Calculate the density of water. Show your calculation.

$$\text{Density of Water: } \frac{m}{V} = \frac{5.82}{6.05} = 0.962 \text{ mL}$$

Part 2: Density of Coke and Diet Coke

Using steps 1-5 above as a guide, determine the densities for Coke and Diet Coke. Write down the procedure you used and the measurements you made. Show all work. You may wish to construct a data table to record your measurements and calculations. Use no more chemical (Coke or Diet Coke) than necessary to obtain a reliable density value, i.e. use less than 10-mL each.

	Coke	Diet Coke
1) mass of grad. →	36.78 g	36.83
2) Volume →	5.05 mL	7.05 mL
3) mass gr. →	41.62 g	43.47 g
4) mass	4.84 g	6.64 g
5) D	0.96 g/mL	0.94 g/mL

Part 3a: Density of a Penny by Direct Measurement

- 1) Take a pre-1982 penny and measure the mass of the penny.
- 2) Find the radius of the penny. It will most likely be easier to measure the diameter of the penny (in cm).
After finding the diameter, divide the diameter by 2 to obtain the radius.
- 3) Find the height of the penny (in cm).
- 4) Calculate the volume of the penny.
- 5) Calculate the density of the penny

$$D = \frac{d}{2}$$

Repeat this same process for a post-1982 penny and record the values.

	Pre-1982 Penny	Post-1982 Penny
Mass of Penny (g)	3.09 g	2.49 g
Diameter of Penny (cm)	1.85 cm	1.85 cm
Radius of Penny (cm)	0.925 cm	0.925 cm
Height of Penny (cm)	0.13	0.13
Volume of Penny (cm ³) ($V = \pi \times r^2 \times h$)	$\pi \times 0.925^2 \times 0.13$ $= 1.4 \text{ cm}^3$	$= 1.4 \text{ cm}^3$
Density of Penny (g/cm ³)	2.21 g/cm ³	1.78 g/cm ³

Part 3b: Density of a stack of Pennies by Direct Measurement

- 1) Take 5 pre-1982 pennies and measure the mass of all of them together.
- 2) Find the radius of the penny. It will most likely be easier to measure the diameter of the penny (in cm). After finding the diameter, divide the diameter by 2 to obtain the radius. This should be approximately the same value as obtained in part 3a.
- 3) Find the height of the stack of pennies (in cm).
- 4) Calculate the volume of the stack of pennies.
- 5) Calculate the density of the pennies.

Repeat this same process for a stack of 5 post-1982 pennies and record the values.

	Pre-1982 Pennies	Post-1982 Pennies
Mass of 5 Pennies (g)	14.28 g	13.14 g
Diameter of Pennies (cm)	1.85 cm	1.85 cm
Radius of Penny (cm)	0.925	0.925
Height of Penny (cm)	0.72 cm	0.72 cm
Volume of Penny (cm ³) ($V = \pi \times r^2 \times h$)	1.94 cm ³	1.94 cm ³
Density of Penny (g/cm ³)	$\frac{14.28}{1.94} = 7.36 \text{ g/cm}^3$	$\frac{13.14}{1.94} = 6.77 \text{ g/cm}^3$

Volume of a Solid by Displacement

Smaller objects and objects with irregular shapes may not be easily measured directly. With a penny, the height is rather small. Another method for determining the volume might be more appropriate.

In the method of finding the volume by displacement, you will first measure a known volume of water. Then, you will add your object to the water. Assuming that the object is denser than water, the object will displace the water to a higher volume. That change in the volume will be the volume of water displaced, and hence the volume of the object. Key concepts to realize with this method are:

- A submerged object displaces a volume of liquid equal to the volume of the object.
- One milliliter (1 mL) of water has a volume of 1 cubic centimeter (1 cm³).
- Objects with the same mass but different volume have different densities.

Part 4: Density of a Penny by Displacement

- 1) Take five pre-1982 pennies and measure the mass.
- 2) Add 5-10 mL of water to a 25-mL graduated cylinder. Record the volume of the water to the nearest tenth of a milliliter.
- 3) Add the five pennies to the water, making sure not to splash and lose any of the water.
- 4) Record the new volume of the water after the addition of the pennies.
- 5) Calculate the volume of water displaced by subtracting the volume of water from the volume of the water after the pennies have been added.
- 6) Calculate the density of the pennies to the correct number of significant figures.

Repeat steps 1-6 for the post-1982 pennies.

	Pre-1982 Pennies	Post-1982 Pennies
Mass of Pennies (g)	14.28g	13.14g
Initial Volume of Water (mL)	10.05 mL	10.05 mL
Volume of Water and Pennies (mL)	10.39 mL	10.39 mL
Volume of Pennies (cm ³)	0.34 mL	0.34 mL
Density of Pennies (g/cm ³)	42 g/cm ³	38.65 g/cm ³

Part 5: Density of a marble.

Using any of the above experiments as a guide, determine the density of the marbles provided. Write down the procedure you used and the measurements you made. Show all work. You may wish to construct a data table to record your measurements and calculations.

	orange marble	green marble
mass of marble	5.91g	5.03g
Initial Volume of water	10.05 mL	9.95 mL
Volume of water and marble	11.5 mL	12.05 mL
Volume of marble	1.45 mL	2.1 cm ³
Density of marble	3.51 g/cm ³	2.4 g/cm ³